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REPORT

OF COMMITTEE ON

HARVARD UNIVERSITY
DEPARTMENT OF
LIBRARY ARCHIVES

AUXILIARY HIGH PRESSURE FIRE PROTECTION WATER SUPPLY

TO THE

COURT OF COMMON COUNCIL

OF THE

CITY OF HARTFORD, CONN.

MARCH 5, 1907

HARTFORD, CONN.:
THE WARD PRINTING COMPANY.
1907.

REPORT

OF COMMITTEE ON

Auxiliary High Pressure Fire Protection Water Supply

TO THE

COURT OF COMMON COUNCIL

OF THE

CITY OF HARTFORD, CONN.

MARCH, 5, 1907.

8 Dec 1910
Harvard University
Dept. of Landscape Arch.
Gift of
Prof J. S. Pray

258

REPORT.

To the Honorable Court of Common Council of the City of Hartford, Conn:

Agreeable to your instructions, your committee on an auxiliary fire protection system of high pressure fire mains for the City of Hartford, begs leave to submit the following report:

RESOLUTION CREATING THE COMMITTEE ON A HIGH PRESSURE WATER SYSTEM FOR THE CITY OF HARTFORD.

On April 30, 1906, your Honorable Body passed the following resolution:

RESOLVED, That the President of the Board of Fire Commissioners, the President of the Board of Street Commissioners, the President of the Board of Water Commissioners and the City Engineer be, and they are hereby, instructed to report to the Court of Common Council, after proper investigation, a detailed plan for an auxiliary system of fire protection for the business section of the city, consisting of a central pumping station at the river with a system of high pressure fire mains, with hydrants to which hose could be directly attached, and in addition to connect the same with the Garden Street reservoir to provide an ample supply of water for washing the streets nightly in the East Side and business sections, with an estimate of the cost of the equipment and construction based on the extension of the work over a series of years.

Approved, May 10, 1906.

Attest,

HENRY F. SMITH, *City Clerk.*

In October of the fall following, your committee met and organized with President Joseph M. Birmingham, of the Water Board, Chairman, and City Engineer F. L. Ford, Secretary. At this meeting City Engineer Ford and Engineer E. M. Peck of the Water Department were authorized and instructed to prepare the detailed report for the committee.

INTRODUCTION.

The art of the fire protection engineer is rapidly coming to be one of the most important in the whole field of engineering. Improved materials, together with increased knowledge of methods of construction, have made it possible to concentrate immense structural values under one comparatively small roof. The grouping of such risks in the congested business portions of our larger cities, even with their so-called fireproof or fire-resisting construction, does not materially lessen the danger from the increasingly frequent conflagrations to which our cities are subject. With improved methods of construction, coupled with all the modern devices of pumps, standpipes, hose connections, sprinklers, water curtains and what not, together with a thoroughly equipped, up to date fire department, the modern fire protection architect and egineer endeavors to surround his risk with every safeguard only to be cruelly disappointed some day at seeing the monument to his genius swept of everything inflammable and seriously damaged as well by a conflagration among unprotected adjacent buildings.

Beautiful fronts, stately columns and strong piers of stone become terribly spalled and disfigured; steel members, designed and constructed with the greatest factors of safety, expand and warp under the tremendous heat and frequently wreck their walls. Captain Stephen S. Sewell, Corps of Engineers, U. S. A., estimated that the cost of restoring the fire-proof buildings damaged in the Baltimore conflagration would be not less than 60% of the original cost of the buildings. His estimate of loss on the various items of the buildings is as follows:—

Steel frame	10%
Outer walls	50%
Floor systems	50%
Partitions	90%
Column coverings	100%
Mechanical equipment	100%
Trim and finish	100%
Office furniture	100%
Contents of vaults	25%

Rarely, if ever, is a properly constructed fire-proof building seriously damaged by an internal fire. The foregoing figures, however, exhibit the dangers to which they are exposed from an external one.

Tables of fire losses covering a number of years show that nearly one-third of the fire loss of the country is due to the exposure hazard. Fire is communicated from one building to another in almost every case through wall openings, through doors or windows, and to provide against this danger fire protectionists have directed some of their best endeavors.

In this connection it may be noted that while the landlord may derive some 40% or 50% benefit from "fire-proof" construction in case of fire, the tenant is no better off than he would have been in a non-fire-proof building, as his is a total loss in any case. In all of our older and larger cities there are places in the congested districts where, under a set of conditions far from improbable, a conflagration would be unavoidable. It is needless to say that these points are the cause of the greatest anxiety to the alert and watchful fire chief, and it is with apprehension that he hears an alarm rung in from a box in their vicinity. A drouth, a strong southwest wind, an undisciplined fire department, and a cow to kick over a kerosene lamp among the straw of a stable, combined to produce one of the greatest conflagrations in all history in Chicago. An innocent little flame in a bale of cotton on the water front at Hoboken caused the loss of 150 lives and millions of dollars worth of property. A common everyday fire in a small drygoods house in Baltimore one Sabbath morning, under the influence of a strong wind, resulted in a conflagration which left a property loss of $75,000,000.00 in its wake. Fire-proof construction may prevent the spread of a fire if it originates in the building in which such construction is employed, as it may act as a retardent if such buildings are grouped in sufficient numbers across the path of a conflagration. Chemical engines in the hands of an efficient fire department may prevent a high percentage of fires from spreading beyond the limits of the room in which they start; but when for any cause the flames leap beyond the limit of such control, the only agent thus far discovered capable in any sense of meeting the exigency is the old traditional enemy of fire—water; not water in little thin streams, but water in huge quantities from powerful appliances in the hands of fearless, intelligent firemen.

The following table prepared by the National Board of Fire Underwriters exhibits the most important fires in the United States and Canada between the years 1820 and 1905:

Date	Place		Property Destroyed	Loss
1820	Savannah, Ga.	463	Buildings	$4,000,000
1835	New York, N. Y.	530	Buildings	15,000,000
1838	Charleston, S. C.	1,158	Buildings	3,000,000
1845	New York, N. Y.	300	Buildings	7,500,000
1845	Pittsburg, Pa.	1,100	Buildings	10,000,000
1848	Albany, N. Y.	600	Buildings	3,000,000
1849	St. Louis, Mo.	15	Blocks	3,000,000
1850	Philadelphia, Pa.	400	Buildings	5,000,000
1851	San Francisco, Cal. (May)	1,000	Buildings	10,000,000
1851	San Francisco, Cal. (June)	500	Buildings	3,000,000
1866	Portland, Me.	1,743	Buildings	10,000,000
1871	Chicago, Ill.	17,430	Buildings	168,000,000
1872	Boston, Mass.	776	Buildings	75,000,000
1879	New York, N. Y.		Drygoods buildings	3,500,000
1881	Quebec, Que.		One-fifth of city	$2,000,000
1889	New York, N. Y.		Elevators & wharves	3,000,000
1889	Seattle, Wash.		Business section	5,000,000
1889	Spokane, Wash.		Large part of city	6,000,000
1889	Boston, Mass.		Bedford St. Buildings	6,000,000
1889	Lynn, Mass.	300	Buildings	5,000,000
1892	New Orleans, La.		Drygoods district	3,000,000
1892	New Orleans, La.		Business district	3,000,000
1892	St. Johns, N. F.	600	Buildings	25,000,000
1892	Milwaukee, Wis.		Business buildings	6,000,000
1893	Boston, Mass.		Business buildings	4,500,000
1895	San Francisco, Cal.		Factory and buildings	2,000,000
1897	Newport News, Va.		Buildings and ships	2,000,000
1897	Pittsburg, Pa.		Business buildings	2,000,000
1897	Windsor, N. S.		Entire town	2,500,000
1898	Pittsburg, Pa.		Chautauqua building	2,000,000
1898	San Francisco, Cal.		Baldwin's Theatre	2,000,000
1898	Terre Haute, Ind.		Business section	1,850,000
1899	Dawson City, B. C.	111	Buildings	3,000,000

Date	Place		Property Destroyed	Loss
1899	Victor, Colo.	800	Buildings	$ 2,000,000
1899	Philadelphia, Pa.		Business block	3,000,000
1899	Ottawa & Hull, Canada		Large section	15,000,000
1900	Hoboken, N. J.		Piers and vessels	5,500,000
1900	Bayonne, N. J.		Oil Works	4,500,000
1901	Montreal, Que.		Business buildings	3,000,000
1901	Jacksonville, Fla.	148	Blocks	11,000,000
1902	Waterbury, Conn.		Business blocks	3,000,000
1902	Paterson, N. J.	26	Business blocks	7,000,000
1903	Cincinnati, O.		Opera House, etc.	2,000,000
1904	Baltimore, Md.		General conflagration	75,000,000
1904	Rochester, N. Y.		Business blocks	3,000,000
				$539,850,000

The frequency and danger of these conflagrations have resulted in a demand for a water supply for fire-fighting purposes quicker and more powerful to operate than through the medium of a fire engine, and in greater and more constant volume than that of the average municipal supply.

The inefficiency of steam fire engines is well known. The following is from the report of the committee on "High pressure system for fire services" of the National Fire Protection Association, and is "a summary of recent tests of steam fire engines picked at random from service equipment of many of the best city departments in the country:—

Number of engines tested	102
Nominal capacity	69800
Actual capacity	55900
Percentage of efficiency	80%

"In many cases the efficiency of individual 'steamers' is less than 50%."

The demand for an improved fire-fighting water supply has been met by the construction in some cities of an independent system of high pressure fire mains capable of delivering huge quantities of water with small loss of head under high pressures produced either by powerful pumps or by high level standpipes or reservoirs. It is a far cry from

the old-fashioned hand-braked fire engines of the volunteer fire companies of a few decades ago to the monitor of a modern fire boat whose powerful pumps are capable of forcing from it a 4" stream of water to a distance of 200 ft. and melting down a 12" brick wall like so much brown paper. This is only an example of what science is doing for the art of fire fighting in modern times.

Already Philadelphia, Newark, Milwaukee, Detroit, Cleveland, Buffalo, Rochester, Coney Island, Providence, Boston, Lawrence, Fitchburg and Worcester have such plants in operation; Winnipeg, Manhattan, Brooklyn and Toronto are constructing; Baltimore, Atlantic City, Chicago and Salem, Mass., have reports and plans ready for action by their Common Councils; and a number of other cities like our own are considering the matter seriously. Our own city is unique among American cities for banking and insurance interests, and it is eminently fitting that the home city of so many fire insurance companies should early evince an interest in and investigate the value of an independent high pressure fire system.

The following pages will be occupied with a discussion of this subject in general and the application of its principles to Hartford in particular. It must be borne in mind that this is a preliminary report only. The maps and drawings presented are intended to illustrate on broad lines the general character of an auxiliary fire service, and are not finished plans for construction purposes.

It may be said, however, that while in a finished report, after careful study, changes might be made in the location of mains and appurtenances, or in the location and equipment of the power station, we are safe in considering that such a system can be built according to the general lines and within the estimate herein presented.

DIFFERENT SYSTEMS COMPARED.

Independent lines of high pressure fire mains have been constructed for some years in American cities, but the present high degree of development of such systems is of very recent date.

The scarcity and newness of these systems makes reliable information, particularly information regarding their maintainance, operation and efficiency, very difficult to obtain. Regarding the manner in which pressure is applied, these systems are naturally divided into two great classes, viz., gravity systems and those in which the pressure is applied by rotary

or reciprocating pumps. The latter class may be again divided into two sub-classes depending upon whether the pressure is applied from a fixed pumping station on land or from fire boats. Gravity systems usually carry comparatively low pressures, 180 lbs. being the highest which has come to our notice. The details of their construction are practically the same as those where pumps are used, with the exception, of course, that no pumping station is required and consequently no telephone system.

This tends to make them much cheaper to maintain and operate than pumping systems. Gravity systems are exemplified in Newark, N. J., Providence, Lawrence, Fitchburg and Worcter. Systems having pressure applied from a fixed pumping station form the highest type of fire supplies that we have. They often sustain pressures of 300 lbs., and call for great care both in design and construction.

Cities having such systems are Philadelphia, New York, Brooklyn, Coney Island, Winnipeg and Toronto.

Systems supplied by pressure from fire boats are the oldest that we have; and those having it applied from fixed stations may be considered as evolved from them. Fire boats carrying powerful pumps and nozzles, capable of discharging large streams of water to great distances, have been in use for many years for protecting the developed water fronts and shipping of cities located upon navigable bodies of water.

Since the development of these cities has been almost invariably from these water fronts inland, it transpires that their congested business districts are in nearly every case situated in close proximity to them. With fire boats patrolling the shores it was most natural to lay lines of pipe with fire boat connections from the water fronts back into the congested districts. Cities supplied with such systems are Detroit, Cleveland, Buffalo and Boston. The pressures on these systems are usually intermediate between those of gravity systems and those having fixed pumping stations. They are costly to maintain because steam must be kept up constantly. They lack in quickness and ease of operation and consequently in efficiency, for the reason that usually they are drained to prevent their freezing at the water front, and time is lost in filling them; in case of an alarm being rung in adjacent to a line at a distance from the boat, much time is lost in getting the boat in position and making connections. In the case of bodies of water where much ice is formed, this is a very serious objection. The following table exhibits the characteristics of the systems, present and proposed, in different cities in the Unted States and Canada:

City	Estimated Population	Date of Installation	Source of Pressure	Gallons per minute	Maxi'm Pressure lbs.	Lineal ft. of Mains	Sizes of Mains in inches	No. of Hydrants	Total Cost of System	No. of Acres	Cost per Acre	Connection with Buildings	Effect on Insurance Rates
Atlantic City	40,000	Proposed	1 Station Electric Turbine Pumps	7,000	225	38,590	8-14	82	$ 187,272	306	$ 612.		
Baltimore	575,000	Proposed	Pumping Station			75,900	10-20		* 397,999	360		Standpipes on Buildings	
Boston	620,000	1898	Fire-boat	6,000	200	4,700	12	14	30,080	65	463.		
Brooklyn	1,400,000	Construc'g	2 Pumping Stations Electric Turbine Pumps	32,000	300		8-20		1,384,500	1420	975.		
Buffalo	420,000	1897	3 Fireboats		300	12,756	12						Reduction of 30 cts. per $1000
Chicago	2,100,000	Proposed	1 Station Gas Triplex Pumps	30,000	300	268,900	8-36	850	3,203,480	1280	2503.	No Open Connection	Reduction of 25% assumed
Cleveland	480,000	Construc'g	To have Pumping Station At present 2 Fireboats	10,000	300	32,524	8-20	96	* 170,000	338		May have Connection with Auto. Sprinklers	Reduction of 80 cts. per $1000 proposed
Coney Island		1905-6	1 Station Gas Triplex Pumps	3,600	150		8-16		90,000	147	612.		Reduction of 25%
Detroit	380,000	1893	2 Fire-boats	10,000	210	25,831	8-10	95		356	135.		Probably has prevented an increase
Fitchburg	33,000		Gravity †		180	28,250	8-16		50,000	346	144.	Boiler Feed, Elevators and Sprinklers	Prevented an increase
Hartford	98,000	Proposed	1 Station	10,000	300	53,430	8-24	198	796,277	731.3	1089.	No Open Connection	
Lawrence	75,000	1906	Gravity †		134	10,200	10-12	39		120			No Change
Milwaukee	340,000	1889	3 Fire-boats	15,000	250	45,717	6-12	183		630			10% Reduction
Newark	290,000	1905	Gravity	3,500	165	15,000	20-30	52	135,000	303	446.	Some Connections	10% Reduction
New York (Manhattan)	2,100,000	Construc'g	2 Stations Electric Turbine Pumps	30,000	300		12-24	1200	3,950,400	1430	2763.	Water Curtains provided for	No Change
Philadelphia	1,500,000	1903	1 Station Gas Triplex Pumps	9,100	300	35,300	8-16	166	700,000	512	1367.	None on or in Buildings	Penalty of 25% removed ‡
Providence	200,000	1897	Gravity	3,472	116	29,409	12-24	89	143,136	358	400.	5 Automatic Sprinklers	No Change
Rochester	185,000	1874	2 Stations—Elec. Tur. P'p Steam Tur., Tur. Pump	9,000	140	102,960	4-20					Some Connections	Graded Reduction
Toronto	215,000	Construc'g	1 Station Electric Turbine Pump	14,000	300	40,000	8-20		500,000	287	1742.	Considering Connection	Uncertain
Winnipeg	110,000	Construc'g	1 Station—Gas Producer, Gas Eng., Triplex Pumps	10,800	300	15,840	8-20		650,000	275	2364.	Connection with Automatic Sprinklers	Uncertain
Worcester	138,000		Gravity †		165	100,320	8-30			1380		Elevators	No Change

* Exclusive of Pumping Station and Equipment.
† System consists of extension of pipes from high service into district covered by low service.
‡ Board of Fire Underwriters have voted to reduce rates to the amount of 10 cents per $100. ⇒A total of $40,000 if extensions costing $150,000 are made to the system.

SYSTEMS MOST APPLICABLE TO HARTFORD.

While, in the resolution passed by your Honorable Body creating a committee on a High Pressure Water System, it was stipulated that a system having a central pumping station should be reported upon, your committee may be pardoned for drawing certain conclusions regarding the application of other systems to the conditions prevalent in our city. As has been seen, some cities are fortunate in having a high-level reservoir for domestic water supply lying either near the city or connected with it by mains of such capacity as to eliminate the objection to loss of head. Particularly was this the case in Newark, N. J., where from a reservoir with a water line elevation of 375 ft. above the street level there is a 60" steel main running nearly to the heart of the city. No. 6 reservoir has an elevation at water line of 400 ft., which would give a static head of about 335 ft. at street level at City Hall, 40 ft. less than the static head in Newark's system.

In order to make this valuable as a fire protection supply, it would be necessary to lay a very large and expensive supply main, and large distribution mains in nearly every street in the area protected. So far as a system operated by fire boats is concerned, Hartford has a very short developed water front, and it seems extremely improbable that she will have a much longer one for a great many years to come at least.

Inasmuch as she has not needed a fire boat in the past, there is no occasion to think that she will require one in the future; and the disadvantages of, and objection to, the use of a fire boat for pumping to a system of fire mains are so numerous and obvious, and all common to Hartford, that the installation of one for this purpose alone should be, and is, out of the question.

AREA TO BE PROTECTED.

The limits of the area which it is proposed to cover are practically those of the conflagration area as fixed by the New England Insurance Exchange, and include 731.3 acres or about 1.14 square miles. Though a small area comparatively, it is quite diversified from a topographical standpoint. It rises gradually from the Connecticut River to Main Street, then falls off westward to Gully Brook Valley, from which it again rises rapidly toward Garden Street. The Park River runs through the southern portion of the area, and the ground rises northward and

southward from it. The highest portions of the area are about at the intersections of Main and Trumbull Streets, and of Church and Spring Streets, both of which are approximately 75 ft. above mean low water in Connecticut River.

The most congested portion of the district presents the usual aspect of fire-proof and improved risks surrounded by non-fire-proof buildings so common in nearly all of our larger cities. In general the buildings run from 4 to 6 stories in height. There are two buildings 7 stories high and one 8. The highest building is the new building of the Travelers Ins. Co., which has 9 stories, and including the roof house, 10 stories. The top of the cornice of this building measures 132 feet above the sidewalk at the corner of Main and Grove Streets, and to the extreme top of the roof house it is 150 feet.

AMOUNT OF WATER USED AT FIRES.

Information upon this subject is very meagre, very little attention, as a rule, being paid to it by public officials. In looking through the annual reports of the fire departments of 35 cities situated all over the United States, your committee was unable to find anything upon this subject.

In Boston in 1892 the per capita consumption for fires was determined, partly measured and partly estimated, at .10 gallons; in Fall River for the year 1899 the amount similarly arrived at was .11 gallons. Folwell in his "Water Supply Engineering" estimates the annual rate per capita for fire purposes at about .08 to .12 gallons per day.

The following tables showing the amounts of water used for fire purposes in the Boroughs of Manhattan and Brooklyn for the years 1900. 1901, 1902, 1903 and 1904 are from a "Paper on the High Pressure Fire System in the Borough of Manhattan" by Mr. I. M. de Varona, Chief Engineer, Department of Water Supply, Gas and Electricity, of New York.

Water Used, Borough of Manhattan.

1900	60,258,679 gals.	of which	27,955,325 gals.	were	river water
1901	99,228,572 gals.	of which	69,552,105 gals.	were	river water
1902	49,032,542 gals.	of which	16,136,150 gals.	were	river water
1903	80,342,443 gals.	of which	17,920,000 gals.	were	river water
1904	81,191,779 gals.	of which	23,721,059 gals.	were	river water

Average for the above five years:

74,010,803 gals. of which 31,056,928 gals. were river water

Daily average for the above five years ..... 117,000 gallons

Water Used, Borough of Brooklyn.

1900	50,126,363 gals.	of which	22,584,630 gals.	were river	water
1901	64,038,745 gals.	of which	36,948,130 gals.	were river	water
1902	38,827,222 gals.	of which	13,797,420 gals.	were river	water
1903	22,691,120 gals.	of which	4,368,750 gals.	were river	water
1904	42,844,391 gals.	of which	17,355,710 gals.	were river	water

Average for the above 5 years:

43,705,568 gals. of which 19,010,928 gals. were river water

Daily average for the above 5 years ..... 67,000 gallons.

WATER WAS USED ON INDIVIDUAL FIRES AS FOLLOWS:

BOROUGHS OF MANHATTAN AND THE BRONX.

October 29, 1900. Tarrant fire, 276-280 Greenwich street, of 22 hours duration; amount of water used, 330,000 gallons.

January 31, 1901. Wicks fire, 538-544 First avenue, 10 hours duration; amount of water used, 150,000 gallons.

February 22, 1902. 71st Regiment Armory, east side of 4th avenue, between 33d and 34th streets, 61 hours duration; amount of water used, 900,000 gallons.

December 21, 1903. 188-194 Mott street, 106 hours duration; amount of water used, 1,590,000 gallons.

March 26, 1904. 61 Broadway to 39-41 Trinity place, 5 hours duration; 75,000 gallons of water used.

BOROUGH OF BROOKLYN.

April 9, 1900. 8 one-story, 12 two-story, 2 three-story lumber yard fire, S. S. Newton Creek, 7 hours duration; amount of water used, 105,000 gallons.

April 30, 1901. 558-578 Flushing avenue, B. R. T. car sheds, 3 hours duration; amount of water used, 45,000 gallons.

May 2, 1902. 239-245 Willoughby street, 5-story brick 120'x150'. Freeborn G. Smith Piano Manufactory, Storage, 3 hours duration; amount of water used, 45,000 gallons.

These figures make it apparent that the amount of water actually required for fire extinguishment is so ridiculously small as to be negligible in planning a water supply for a municipality. The trouble

about water for fire purposes has never been with the supply, but rather with the ability of the plant to concentrate it at the points where it was needed.

RELATION OF POPULATION TO AMOUNT OF WATER REQUIRED.

Under the most favorable circumstances the distribution systems of domestic water supplies are seldom planned for more than from 20 to 30 years in the future. In a system of deep and expensive construction like the one under consideration, however, in an old section of the city, with street lines and grades little subject to change, it seems wise to plan for much further in the future than is customary in ordinary municipal supplies; your committee therefore have planned a system for 40 years in the future.

Estimates of future population are fickle and in fact very little more than scientific guesses. In his report to the Board of Water Commissioners of Hartford, in 1902, Mr. Allen Hazen, Consulting Engineer of New York, estimates the population of Hartford in 1940 at about 186,000. In 1947, or 40 years hence, therefore, we might expect it to be in the neighborhood of 200,000.

The following table is an extract from a larger one in Turneaure and Russell's "Public Water Supplies," and epitomizes the conclusions of different eminent investigators upon the amount of water required for fire purposes in relation to population. It is based upon a stream volume of 250 gallons per minute.

TABLE NO. 4.

	Number of Fire Streams		Required	Simultaneously
Population	Freeman	Fanning	Shedd	Kuichling
100,000	20-30	18	22	28
150,000		25		34
180,000			30	38
200,000	30-50			40
250,000				44

A survey of the table shows that both Freeman and Kuichling consider that for a city of 200,000 about forty 250-gallon fire streams per minute, or a total of 10,000 gallons per minute, may be required simultaneously. While this table was prepared for the city as a whole, it may be said that with a conflagration area as large as ours in comparison with the remainder of the city, the whole amount is quite as likely to be required within its limits as otherwise. It is evident from the above table that the population may vary widely without greatly affecting the number of fire streams required.

Mr. Freeman estimates that, as a general statement, two-thirds of his estimated number should be capable of being concentrated upon any one square in the compact, valuable part of the city, or upon any one large building of special hazard.

The following table, compiled from the reports of the Fire Marshal of the City of Hartford, shows the probability of the whole amount of water deemed necessary being required within the area proposed to be covered:

TABLE NO. 5.

	In Conflagration Area		Outside Conflagration Area	
Years	No. of Alarms	Net Loss	No. of Alarms	Net Loss
1903	123	$48,549 00	77	$12,492 50
1904	140	63,170 00	86	41,750 00
1905	137	152,469 00	95	11,900 00
1906	159	52,585 00	102	35,623 00
Totals	559	$316,773 00	360	$101,765 50

THE DISTRIBUTION SYSTEM.

In planning the distribution system, all the pipes, and especially the main feeders, have been made larger than the exigencies of the near future would demand, for two reasons, viz.:

1. To allow for deterioration of the pipes from tuberculation.

2. In the case of the main feeders, to allow for extension of the system coincident with extension of the conflagration area beyond its present limits.

The theory of the corrosion of the interior of cast iron water pipes with the formation of tubercles is that the metal is attacked by the carbonic acid in the water. The softest waters are worst in this respect, and as Connecticut River water has been shown by analysis to be an unusually soft water, we may expect cast iron pipes carrying it to suffer severely from tuberculation. The tar coating of cast iron pipes was designed to prevent their corrosion, and when thoroughly applied does so to a great extent. Unfortunately, however, the coating is often of poor quality or imperfectly applied, and results in little benefit. There is in the office of the Board of Water Commissioners a specimen of 4" coated cast iron pipe which, after having been in service about 45 years, is in nearly as good condition as when first laid. There is also in the same office a specimen of coated pipe of the same size which had been in service but about 25 years, which is badly tuberculated. Hartford is so peculiarly located naturally with reference to the Connecticut River, and so hemmed in artificially by railroads, that it is extremely improbable that for a great many years to come at least, the city will have any greater developed water front than it has at present. This makes the matter of an additional pumping station, located at any great distance from the present proposed one to meet the exigencies of the future growth of the city, a very expensive one. It has seemed better, therefore, to plan the main feeders of the distribution system much larger than would otherwise be necessary, to provide for these probable extensions. The proposed system comprises 10.12 miles of cast iron mains varying in diameter from 8" to 24". This is exclusive of the pipe required for hydrant connections and blow-offs. The thicknesses and factors of safety of the different sized pipes are exhibited in the following table:

TABLE NO. 6.

Size of pipe	Thickness	Pressure per sq. in. necessary to burst pipe	Factor of Safety
24"	1⅞"	3240	10.8
20"	1½"	3150	10.5
16"	1¼"	3280	10.9
12"	1 "	3500	11.6
8"	⅞"	4590	15.3
*6"	⅝"	4430	14.7

*Used only for hydrant connections.

On account of their weakened sections, the large 3-way and 4-way branches will be made of cast steel, which has a tensile strength about three times greater than that of cast iron.

The joints proposed are of special form, similar to those in use in New York's High Pressure System. They have deep double lead rings in both spigot and bell ends of pipe. In addition to this, wherever there is a curve in the line it is proposed to have lugs cast near the bell end of the pipe section for the purpose of bolting the successive lengths of pipe together longitudinally with long wrought iron rods. Various joints have been invented by the different engineers of high pressure systems, but it has generally come to be considered that neither screw joints nor flange joints are on the whole better than a good lead joint with proper lead grooves. It is barely possible that up to and including the 12" size the plain ordinary lead joint would hold. When, however, the heavy pressures are taken into account, it may be seen readily that a bad break under full pressure might easily prove as disastrous as a fire, and it is wise to provide large factors of safety rather than to take chances. In calculating the pipes, use was made of the Chezy formula as adapted in the tables of Williams & Hazen for cast iron pipes in service, and 35% has been allowed for deterioration.

In that section of the city which contains its finest buildings and its greatest fire hazards, bounded by Front, Arch, Wells, Trumbull, Main, Windsor, Pleasant, Market and Morgan streets, the distribution system has been designed so that, when 40 years of age, it will be able to deliver at any point from 8,000 to 10,000 gallons of water per minute with a loss of head due to friction not to exceed 50 lbs. At City Hall it will be able to deliver 10,000 gallons per minute with a hydrant pressure of 240 lbs.

The following table shows the capacity of the system at different points, with a loss of head from friction not to exceed 50 lbs. at the hydrant and a velocity less than 10 ft. per second, with the mains 40 years old.

TABLE NO. 7.

Location	Gallons per minute	Number of 400-gallon fire streams
Cor. Front & State Sts.,	8,000	20.
Cor. Front & Arch Sts..	8,300	20.75
Cor. Main & Wells Sts.,	10,000	25.
City Hall, Main St.,	10,000	25.
Cor. Pearl & Trumbull Sts.,	10,000	25.
Cor. Main & Trumbull Sts.,	10,000	25.
At Railroad Station,	9.000	22.5
Cor. Walnut & Chestnut Sts.,	8,000	20.
Cor. Windsor Ave. & Belden St.,	10,000	25.
Cor. Russell & Windsor Sts.,	7,500	18.75

The matter of fixing the pressure under which the system should operate was one of considerable solicitation. At first it seemed to your committee that the heavy pressure which the systems in several cities have been designed recently to sustain were quite inapplicable to conditions in Hartford.

Maturer deliberation, however, led them to determine upon a pressure at the pumps of 300 lbs. per square inch. While many fires have to be fought from the outside, it is rarely possible thus to fight one to any advantage, even with a water tower, to a greater height than 9 or 10 stories. In the event of the construction of the proposed system, there is a probability of dry standpipes with hose connection at each floor being made a part of the equipment of the taller buildings. The following table shows the relation between population and the number of stories in the highest buildings in 56 cities in the United States and Canada. In most cases the given height of the buildings is the result either of observation or of reliable information. In the few exceptions the height is sufficiently accurate for practical purposes.

Table showing the relationship between population and number of stories in the highest buildings in 56 cities in the United States and Canada, arranged according to population:

TABLE NO 8.

City	Population	Number of stories in highest buildings	Remarks
Westerly, R. I.	14,000	4	
Clinton, Mass.	14,000	4	
Attleboro, Mass.	15,000	5	
Concord, N. H.	20,000	5	
Middletown, Ct.	20,000	4	
New London, Ct.	20,000	7	
Brookline, Mass.	25,000	4	
Nashua, N. H.	27,000	6	
Taunton, Mass.	31,000	3	
Fitchburg, Mass.	33,000	5	
Woonsocket, R. I.	35,000	5	
Newton, Mass.	37,000	6	

Schenectady, N. Y.	37,000	6
Malden, Mass.	40,000	4
Atlantic City, N. J.	40,000	10
Pawtucket, R. I.	47,000	6
Brockton, Mass.	50,000	8
Holyoke, Mass.	50,000	8
Waterbury, Ct.	70,000	7
Somerville Mass.	71,000	4
Lawrence, Mass.	75,000	8
Manchester, N. H.	75,000	6
Des Moines, Ia.	75,000	9
Lynn, Mass.	80,000	8
Springfield, Mass.	80,000	9
Lowell, Mass.	95,000	7
Bridgeport, Ct.	95,000	8
Albany, N. Y.	95,000	8
Hartford, Ct.	98,000	10
Cambridge, Mass.	100,000	7
Winnipeg, Man.	110,000	11
Fall River, Mass.	114,000	6
Syracuse, N. Y.	125,000	10
New Haven, Ct.	130,000	9
Worcester, Mass.	138,000	9
Columbus, Ohio	150,000	9
Rochester, N. Y.	185,000	13
Kansas City, Mo.	185,000	9
St. Paul, Minn.	185,000	12
Providence, R. I.	200,000	12
Indianapolis, Ind.	215,000	12
Minneapolis, Minn.	250,000	12
Newark, N. J.	290,000	12
Washington, D. C.	310,000	15
Milwaukee, Wis.	340,000	15
Cincinnati, Ohio	347,000	20
Pittsburg, Pa.	375,000	25
Detroit, Mich.	380,000	18
Buffalo, N. Y.	420,000	14
Cleveland, Ohio	480,000	17

Baltimore, Md.	575,000	20	
Boston, Mass.	620,000	14	Limited to 120 ft. high.
St. Louis, Mo.	660,000	17	
Philadelphia, Pa.	1,500,000	24	
Chicago, Ill.	2,100,000	24	Limited to 260 ft. high.
Greater N. Y.	4,000,000	43	In process of construction.

A study of this table shows that the population may vary quite widely without appreciably affecting the probable number of stories. This, of course, can be accepted only as an indication of what may be expected, since the mere fact of numbers can have no effect upon the height of buildings. The table, therefore, would indicate that for a population of about 200,000, the probable population of Hartford 40 years hence, buildings of 12 stories may be anticipated. It will be noticed that Hartford is considerably above its class, reckoned upon the basis of population, and that considering the character of her business interests, buildings higher than 12 stories, perhaps 15 or 16 stories, might be expected. If properly fitted with standpipes and hose connections, the 300 lbs. pressure will be more than sufficient for fire service in such buildings, although it may be stated as a general proposition that a municipality can scarcely be expected to furnish fire protection for one or two abnormally high buildings. What has been most influential in fixing the pressure, has been the lengths of hose necessary to be laid. It has been considered that, no matter how closely the hydrants might be spaced, it might be necessary to lay lengths of hose of 600 ft. The system has been planned, therefore, with the object in view of limiting this length to 600 ft., and in the case of the more important blocks and buildings, to 400 ft. Few people are aware of the tremendous loss of head which occurs in ordinary fire hose when large volumes of water are discharged. The intelligent fire fighter is always solicitous to be able to throw large volumes of water in a single stream on a fire, particularly a large and hot one, as smaller streams are readily converted into steam and do the fire little harm.

The following table is from data derived from experiments of John R. Freeman, and exhibits the volume of fire streams under various conditions with ordinary best quality 2½" rubber lined hose.

TABLE NO. 9.

Size of nozzle.	Lbs. pressure at base of play pipe.	Maximum limit of height as good effective fire stream with moderate wind. Ft.	Maximum limit of distance as good effective fire stream with moderate wind. Ft.	Gallons per minute discharged.	Length of hose.	Lbs. pressure necessary at hydrant.	Lbs. loss of head per 100 ft. of hose.
1 "	100	96	83	295	600	223	20.5
1⅛"	100	99	89	376	400	236	34.
1¼"	95	100	92	456	300	247	51.
1¼"	60	85	76	363	600	245	31.
1⅜"	95	101	94	560	200	254	79.5
1⅜"	75	95	86	497	300	256	60.3
1⅜"	60	87	79	445	400	250	47.5
1⅜"	50	79	73	406	500	245	39.
1⅜"	45	74	70	385	600	254	34.8

The following table was compiled by the National Fire Protection Association from data derived from later experiments of the same eminent investigator, Freeman, and is inserted here because it shows the effect of larger nozzles and of siamesed lines of hose. It gives the pressure required at hydrant to overcome friction loss in hose streams of various lengths and maintain 75 lbs. nozzle pressure, the nozzle being located at the same level. For the 2" nozzle it is assumed that two hose lines, each of the length stated, will be siamesed together.

TABLE NO. 10.

TABLE OF REQUIRED HYDRANT PRESSURES (LBS.)

Hose diameter		2¼"		3"		3½"	
Hose lines		Single	Siam.	Single	Siam.	Single	Siam.
Smooth bore nozzle		1¼"	2"	1¼"	2"	1¼"	2"
Length of hose line	100'	121.	139	92.	101	84.5	88.
Length of hose line	150'	139.	170	99.5	113	87.5	93.5
Length of hose line	200'	158.	201	107.	125	91.	99.
Length of hose line	250'	176.5	232	114.5	137	94.5	104.5
Length of hose line	300'	195.	263	122.	140	98.	110.
Length of hose line	400'	232.	325	137.	173	105.	121.

In planning the distribution the gridiron plan has been followed as closely as economy would allow. Since a pressure of 300 lbs. was decided upon as essential, it became unnecessary to lay mains in every street, which, of course, effects a great saving in money in first cost as well as in possible cost of maintainance. The ideal distribution system is one in which comparatively small districts are surrounded with mains sufficiently large to deliver the greatest amount of water necessary for that district with very small loss of head, the intermediate streets being filled with smaller pipes. The theory is that, when, as in case of a fire, there is a great discharge of water at several points within a small radius, the most of the frictional losses should occur in the small mains in close proximity to the points of discharge. To eliminate the probability of freezing in mains in which no circulation is maintained, and to avoid other underground structures in constructing the system, it has been planned to lay all mains with at least 6′ of covering. The hydrant interval has been made 150′ in the most congested district, shading off to 200 ft. and to 300 ft. on the outskirts.

Not to throw the whole burden of expense of constructing the system at one time upon the city, it has been thought best to divide the district up into three sections which might be constructed successively should the city so desire to do.

SECTION 1. Is enclosed by Front, State, Commerce, Potter, Front, Arch, Main, Trumbull, Main, Windsor and Pleasant Streets, and includes that portion of pipe line falling within the limits of Section No. 2, as follows: Allyn Street from Trumbull Street to High Street, High Street from Allyn to Church Street, Church Street from High to Spring Street, and Spring Street from Church to Myrtle; this latter is for the purpose of connecting with the old 16″ force main to Garden Street Reservoir. This whole project involves 4.32 miles of mains, and the area comprises the principal business portions of the city.

SEC. 2. Is bounded by Pearl, Ford, Asylum, Spruce, Church, Spring, Edwards, Walnut, and Chestnut Streets, Albany Avenue, Belden Street, Kennedy, Donald, Russell, Windsor, Main and Trumbull Streets, and comprises 3.19 miles of mains.

SEC. 3. Is enclosed by Sheldon, Charter Oak Avenue, Main, Park, Hudson, Buckingham, West, and Elm Streets, and comprises 2.61 miles of mains.

GATE VALVES.

No gate larger than 20" will be used, the few necessary for the 24" line being of this size and arranged for by 24"x20" reducers each side of gate. All gates will be of the double disc type, made to stand a test pressure of 500 lbs.

The 20" and 16" gates will be geared and have 4" by-passes; the 12" gates will be geared and have 3" by-passes.

All gates on mains will be set in suitable manholes of brick to insure easy inspection and repairs. Numerous gates have been allowed for, so that in case of a break in the main it will be necesarry to cut out a short section only, thus enhancing the efficiency of the distribution system.

HYDRANTS.

It is proposed to make the hydrants of the well-known gate type, these seeming to possess advantages over compression hydrants where high pressures are employed. The hydrants for fire services will each have four 2½" outlets, quartering, each nozzle being independent gated. They will have 8" barrel, an inlet valve of not less than 6" drip, be arranged for 8" connection with the main, and fitted with frost jacket.

The hydrants for street flushing purposes will have one 2½" outlet, inlet valve not less than 4" drip, be arranged for 6" connection with the main, and fitted with frost jacket. These hydrants will be so constructed as to shut off the supply of water automatically when the pressure reaches a certain number of pounds in the mains, thus preventing injury to the workmen should the pressure be raised suddenly without warning. All hydrants will be made to stand a test pressure of 500 lbs., and all will be cut off from the main pipe by gates.

CONNECTIONS.

What connections, other than fire hydrants, should be made with an independent system of fire mains, is a mooted question among fire protectionists. In this connection one thing which must be taken into consideration is the danger from water-hammer on a system of piping already sustaining heavy pressure. In a system for domestic supply, the

danger from water-hammer is greatly reduced or eliminated entirely by the fact that even if the conditions favorable to it are produced by the sudden closing of several large valves simultaneously, others are opened at the same time, thus affording relief.

In a system for fire service the connections are all large and the conditions favorable to relief do not obtain.

This makes the connection of elevators with these systems, as is done in some places, particularly dangerous and to be avoided. Another objection to the permanent metallic connection of plumbing inside buildings with such systems is the danger of "bleeding" the systems by the breaking of such pipes during a conflagration. This is a common experience in large fires, and during the Baltimore conflagration it is estimated that several hundred pipes, many of them from 3" to 6" in diameter, were broken off and discharging at nearly their full capacity. The danger from this source to a system sustaining from 200 to 300 lbs. pressure can easily be imagined. This latter objection would apply to sprinkler systems and inside standpipes as well as to elevator pipes. Some fire protectionists have countenanced the connection of sprinkler systems and standpipes to the distribution system, provided such connections were properly gated outside in the street, these gates to be closed by the firemen when the fire had gained such headway that the sprinklers could be of no further use.

It has further been advised that to avoid the danger from falling walls, and the intense heat which may be generated, the service pipe should be taken off the main in such a way that it could be gated a certain distance, say 20 feet, one side of the building to be served. The objections to this method are two-fold, viz.:

1. The difficulty of readily finding a gate in the confusion liable to prevail at a large fire, and especially in a macadamized street in the winter time.

2. The danger of the rapid spread of a conflagration preventing the firemen from closing the gates.

In view of these facts your committee have decided to report against any permanent connection whatever between inside plumbing and the distribution system. They would, however, advise the construction of dry standpipes in buildings, with hose connections at each floor, and outside hose connections, so that in case of fire the pipes could be filled by means of lines of hose laid by the firemen between these outside connections and the hydrants.

STREET FLUSHING.

In accordance with the provisions of the resolution creating your committee, we have reported a plan for connecting the proposed system with the Garden Street Reservoir for a water supply for street flushing purposes.

So far as your committee is informed, New York is the only city in which provision has ever been made for flushing the streets with water from an independent fire system, and here street sprinkling was provided for from the same source.

That it was not a very important consideration there, is evidenced by the following paragraph from the "Paper on High Pressure Fire System in the Borough of Manhattan," by Chief Engineer I. M. de Varona:

"After consultation with Commissioner Woodbury to ascertain his wishes in regard to location and number of hydrants, a plan was prepared by this Bureau and approved by the Street Cleaning Commissioner showing the hydrants to be installed for sprinkling and flushing purposes. As the appropriation made for the Borough of Brooklyn did not include the cost of these hydrants, and the Manhattan appropriation is not deemed sufficient to pay for their installation in this Borough, no contract has yet been made for furnishing and installing these hydrants. Sufficient work has been done on the specifications for the same so that they can be readily completed and the contract advertised as soon as the matter is definitely settled and an appropriation obtained."

Superintendent of Streets Hansling estimates that for each street flushing he will require in round numbers 25,000 gallons; and as he intends flushing twice each week, this will consume 50,000 gallons per week, or a little more than 8,000 gallons per day. Mr. Hansling also estimates that for this work the hydrant interval would need to be about 500 feet. For various reasons it would be unwise to permit the use of the fire hydrants for this work, and instead a special hydrant would be employed.

This hydrant would be so designed that the supply of water would be cut off when the pressure reached about 50 lbs.

This precaution would be necessary to prevent injury to the men using them, if for any reason, such as a still alarm, the pressure in the mains should be raised suddenly without warning. These hydrants would all be cut off from the mains by 6" gate valves. It is proposed to make the connection between the high pressure system and the Garden Street

Reservoir by means of a branch cut into the old 16" force main leading to the same, at the intersection of Spring and Myrtle Streets. In this connection would be a check valve so arranged as to cut the reservoir off from the high pressure system when the pressure in the latter reached about 50 lbs. at that point. From the intersection of Trumbull and Allyn Streets, through Allyn, High, Church and Spring Streets, to Myrtle, the main laid would be of the sizes and weights necessary for the construction of the whole high pressure project, as eventually they could be made an integral part of its distribution.

In regard to the whole scheme of connecting the high pressure distribution with the Garden Street Reservoir, it may be said that while the objections to it are numerous, it does not seem to have a single good point to recommend it.

The objections are as follows:

1. The amount of water required for street flushing is so ridiculous ly small as to be of very little consequence so far as depletion of the regular municipal supply is concerned.

2. It is scarcely conceivable that the Board of Water Commissioners would permit any such connection to be made, for the following reasons:

(a) It would be a mixing up of the affairs of the Water Board, Street Board and the city in general, in a manner likely to lead to more or less confusion, if not actual friction.

(b) Since the establishment of a gravity system of supply, this reservoir and its accompanying force main and pumping station have been considered and used as an auxiliary plant for water supply in case of threatened water famine.

(c) The danger of contamination of the domestic supply with tpyhoid fever germs from the raw Connecticut River water, even though the greatest care were exercised in attending the gates at the connection between the two.

3. The water can be furnished much more cheaply from the domestic supply than from the proposed high pressure system.

THE TELEPHONE SYSTEM.

To provide for easy communication between the officers of the fire department and the pumping station in case of a fire, a telephone system will be necessary. After careful deliberation it was thought best to pro-

vide for such a system maintained and absolutely controlled by the city. The proposed system comprises a switch board at its pumping station, with wiring so arranged that in no case more than seven, and in most cases only six, 'phones will be included in one circuit.

At suitable intervals, preferably at street intersections, cast iron uprights and boxes, similar to those now employed for the Fire and Police telegraph signals, will be placed, with wiring such that a portable telephone instrument carried by the chief and his assistants can be attached quickly.

So far as they are available, the underground ducts owned by the city will be employed for the purpose of wiring this system.

POWER HOUSE AND INTAKE.

In planning the power house an attempt was made to locate it as nearly as possible to the section covered by the distribution system, and at the same time isolate it from other buildings which might communicate fire to it. In this matter New York's precedent was followed rather than that of Philadelphia, where the power station is contiguous to non-fire-proof buildings on two sides.

The place selected for its site is on the west bank of the river in Riverside Park, just north of the Hartford Water Works pumping station.

It is planned to place the engines and pumps in a water-tight pump pit of concrete, the top of which will extend above the highest known flood. The bottom of the pit will be at an elevation such that the suction lift of the pumps will be 20 feet with mean low water in the Connecticut River. Ordinarily the suction lift will be less than this, and during floods the pumps will be submerged. The intake will consist of 30" cast iron pipe laid about 3 feet below the bed of the river and terminating in a suitable crib.

MOTORS AND PUMPS.

The matter of selecting the type of pump and the motive power to operate it was one involving much study and investigation. To be efficient for a high pressure fire protection system, the pumping units must have the following qualifications, viz.:

1. They must be so designed and constructed as to be capable of being operated at their maximum capacity in an exceedingly short space of time.

2. The source of power must be such as to be assured practically against everything excepting the direst calamity.

The pumping units mostly in vogue for this class of work are as follows:

1. Producer gas engine driven triplex pumps.
2. Illuminating gas engine driven triplex pumps.
3. Electrically driven turbine pumps.
4. Steam turbine driven turbine pumps.

Gas engines running both upon producer gas and illuminating gas are in successful operation in units larger than any herein contemplated, and have demonstrated their ability to perform the work proposed.

The centrifugal pump has long been known as a very effective machine for pumping large quantities of water against low heads. Its application to the work in question in the form of the multi-stage turbine pump is of very recent date and grew out of the demand for a pump cheap to build and to maintain, and which should be capable of pumping against high heads. These pumps are now built with from one to six or more stages, capable of pumping against heads as high as 2,000 feet. Their construction is exceedingly simple and cheap, and their maintainance is inexpensive, due to the lack of moving parts to be repaired and renewed. Their inherent weakness lies in their low efficiency, which ranges from about 55% to about 72%, and seldom probably exceeds 60% under the most favorable cirucmstances. Then, too, there seems to be a tendency for the efficiency to decrease as the head pumped against increases. If run much either above or below the speed for which they are designed, they do not pump at all, but merely churn water, an undesirable feature, particularly in large units. They operate only at high speed, and for this reason electric motors and steam turbines direct connected are particularly fitted to drive them.

Triplex pumps, while heavy and complex in construction, possess efficiencies usually upwards of 80%. Unlike centrifugal pumps, their efficiency increases as the load increases, while they can be operated successfully at partial load. They run at low rates of speed and are best operated by reciprocating engines, but may be driven by either electric motors or steam turbines. In regard to the source of power, steam, gas, elec-

tricity and oil (as used in an internal combustion engine) were all considered. Steam power seemed practically out of the question on account of the expense of operation consequent upon the necessity of maintaining full boiler pressure constantly. Illuminating gas was considered not to be relied upon owing to the fact that there is but one gas plant in Hartford, and any circumstance which rendered it inoperative would cripple the power station.

Electricity was thought to be especially desirable for power purposes, but the local Electric Light Co. flatly refused to consider any proposition which made it necessary for them to supply so much power at short notice with the probability of a very small income. Among oil engines the "Diesel Engine" was the only one seriously considered. This engine is claimed to possess a fuel efficiency of about 38%, or about 15% greater than that of the best gas engines. If the builders' claim for this engine can be substantiated, it seems to have a great future before it; at present, however, it is too little known to warrant its recommendation for the work herein contemplated. It was decided finally to estimate upon two power plant projects:

The first project involves the use of triplex pumps driven by gas engines adapted to run upon both producer gas and illuminating gas. Ordinarily, illuminating gas would be used; but in case this failed, the producer plant would be in reserve to supply this deficiency.

The pumping units will each be capable of delivering 1,800 gallons per minute, and there will be seven of them—one being in reserve while the other six supply 10,000 gallons per minute plus the water necessary for jacket cooling of the engines and for use in the producer plant. Each unit will consist of a gas engine of the horizontal, four cycle, twin tandem, double acting, four cylinder type, direct connected to a vertical, double acting triplex pump. The producer plant would be of the down draft type, burning soft coal and consisting of two units of normal capacity of 1,000 H. P., each capable of standing safely an overload of 50% for five hours, and in cases of emergency would operate to 100% overload capacity.

The gas holder would have a capacity of containing sufficient gas to operate 6 engines developing 2,500 H. P. for about 40 minutes time. This would give ample time for the producers to be put into operation, starting with everything cold. An air compressor plant for supplying

compressed air to use in one cylinder to start the engines would be provided. The cost of installation, maintainance and operation of the whole system according to this project, assuming that only the first section of the distribution system were built, would be as follows:

POWER STATION.

7 pumps	$ 62,300 00
7 gas engines	114,240 00
Freight	4,010 00
Erection	5,000 00
Piping	15,000 00
Gas producer plant, including holder	55,000 00
House for producer plant	5,500 00
Coal storage plant	10,000 00
Air compressor plant	2,500 00
Power house, complete, including intake	60,000 00
Land	10,000 00
Total	$343,550 00
10% for engineering and contingencies,	34,355 00
Total	$377,905 00

DISTRIBUTION SYSTEM (1st Section).

4350 lin. feet of 8" pipe @ $2.96	$12,876 00
5360 lin. feet of 12" pipe @ 5.10	27,336 00
4750 lin. feet of 16" pipe @ 5.63	26,743 00
6480 lin. feet of 20" pipe @ 9.44	61,171 00
760 lin. feet of 24" pipe @ 12.00	9,120 00
Large hydrant connections	4,236 00
Small hydrant connections	1,365 00
Making connection corner Myrtle and Spring Streets	200 00
24" Venturi meter set up complete with register	1,300 00

90 fire hydrants @ $75.00	$6,750 00
26 street flushing hydrants @ $50.00	1,300 00
26 6" gate valves @ $19.00	494 00
108 8" gate valves @ $28.00	3,024 00
17 12" gate valves @ $55.00	935 00
10 16" gate valves @ $115.00	1,150 00
19 20" gate valves @ $175.00	3,325 00
Telephone system, 31 boxes	11,500 00
46 brick manholes	3,995 00
Total	$176,820 00
10% for engineering and contingencies	17,682 00
Total	$194,502 00
Total Power Station	$377,905 00
Total Distribution system	194,502 00
Grand total	$572,407 00

MAINTAINANCE AND OPERATION.

Fixed charges on distribution system equal 6% on $194,502.00	$11,670 00	
Fixed charges on power plant equal 12% on $377,905.00	45,349 00	
		$57,019 00
Gas per year,	$168 00	
Superintendent per year,	2,000 00	
2 Engineers @ $1,200.00	2,400 00	
4 oilers @ $720.00	2,880.00	
1 Janitor,	600 00	
Oil, waste, etc.,	600 00	
Total		8,648 00
Grand total		$65,667 00

PROJECT NO. 2.

9 units consisting of steam turbines direct connected to multi-stage turbine pumps.

9 units—steam turbines & turbine pumps,	$65,000 00	
Four, 1,150 H. P. boilers,	73,600 00	
Erection,	2,000 00	
Piping,	15,000 00	
Boilerhouse,	11,300 00	
Stack,	14,500 00	
Power house, complete with intake,	32,800 00	
Coal pocket, track, etc., complete,	10,000 00	
Land,	10,000 00	
Total		$234,200 00
10% for engineering & contingencies		23,420 00
Grand total		$257,620 00
Cost of distribution system same as in Project No. 1		194,502 00
Total cost of system		$452,122 00

MAINTAINANCE AND OPERATION.

Fixed charges on distribution system equal 6% on $194,502.00	$11,670 00	
Fixed charges on power plant, equal 15% on $257,620.00	30,914 00	
		$42,584 00
Coal per year,	$35,040 00	
Superintendent per year,	2,000 00	
2 engineers @ $1,200.00 per year,	2,400 00	
4 firemen @ $720.00 per year,	2,880 00	
3 stokers @ $600.00 per year,	1,800 00	

1 Janitor,	$600 00	
Oil, waste, etc.,	600 00	
		$45,320 00
Total		$87,904 00
Cost of operation and maintainance by Project No. 1		65,667 00
Balance in favor of Project No. 1		$22,237 00

By either of these projects your committee believe that the machinery could be started and pumping at its full capacity inside of two minutes. In view of the foregoing figures, your committee recommends the system operated by gas engine driven triplex pumps. The cost of constructing the whole of the proposed system at one time, to be operated by gas engine driven triplex pumps, would be as follows:—

Power plant	$377,905 00
Distribution system:—	
Section No. 1	194,502 00
Section No. 2	139,551 00
Section No. 3	84,319 00
Total	$796,277 00

The matter of designing, financing, construction, operating and maintaining these systems seems to be practically the same in all cities. They are usually constructed under an appropriation made for that purpose by the Court of Common Council. The city of Winnipeg was unique in this respect, its system being constructed under what is known as "The Local Improvement Act," whereby the cost of construction is paid by all property benefited, at a uniform rate per foot of street frontage, in annual installments extending over 20 years. Since this report was begun we understand that Chicago has voted to construct its proposed system with money obtained by a method of assessment similar to Winnipeg's. In nearly all cases the systems are operated and maintained by the fire department.

ACKNOWLEDGMENTS.

In conclusion we wish to make the following acknowledgments:

To Chief Krug and Assistant Chief Loomis of the Fire Department, for much valuable advice regarding the distribution system; to Mr. G. W. Hamilton, Superintendent of the Fire Alarm Telegraph System of Hartford, who kindly prepared the estimate of cost of the telephone system; to the Pratt & Cady Co. and the Terry Steam Turbine Co., of Hartford, who furnished much valuable cost data; and to all the heads and employees of the various city departments specially interested in this matter, for their kind attention and assistance.

Respectfully submitted,

BOARD OF FIRE COMMISSIONERS,
CHARLES E. PARKER, *President.*

BOARD OF STREET COMMISSIONERS,
JOSEPH BUTHS, *President.*

BOARD OF WATER COMMISSIONERS,
J. M. BIRMINGHAM, *President.*

FREDERICK L. FORD, *City Engineer.*

ERMON M. PECK, *Consulting Engineer.*

March 7, 1907.

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